ASIAEX Scattering Strength and Subbottom Geoacoustic Inversions

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LONG-TERM GOALS

The long-term goals of this work are to develop processing approaches that enable the estimation of both seafloor scattering strength and subbottom geoacoustic parameters from monostatic and bistatic scattering observations.

OBJECTIVES

The objectives of this research are to develop inversion procedures for the estimation of both seafloor scattering strength and subbottom geoacoustic parameters based on both forward propagation data and monostatic backscatter (reverberation) and to demonstrate their use in the analysis of data collected during the East China Sea component of ASIAEX.

APPROACH

Sophisticated modeling of seafloor scattering involves the incorporation of a large number of waveguide parameters in full-wave propagation models. When the waveguide parameters are known, substantial success has been achieved in using these models to predict reverberation observations from at-sea experiments. When some of the waveguide parameters are not known, various techniques have been developed to invert for or estimate these parameters with low frequency data (e.g. both simulated annealing (SA) and genetic algorithm (GA) approaches have been used quite successfully). The focus of this research is on the development of higher frequency inversion procedures for both forward propagation and monostatic backscatter (reverberation) data.

The East China Sea component of ASIAEX took place 29 May – 9 June 2001 primarily in 105 m deep water approximately 560 km ESE of Shanghai, P.R. China and 380 km NNW of Naha, Okinawa. Both acoustic propagation and scattering data were collected during the experiment over a broad range of frequencies (100 Hz – 20 kHz) as well as substantial environmental data (e.g. water column sound speed, current structure, wind speed, sea surface wave spectra, and surficial seafloor characteristics) [1].

The specific acoustic data collected by our group included both forward propagation (source tow) and monostatic backscatter (reverberation) data. The forward propagation data were recorded on a 16-element, 75 m aperture, autonomous vertical receive array. Radial source tow tracks were carried out in two frequency bands: (1) 95 Hz – 905 Hz (CW tonals at 95, 195, 295, 395, 805, 850, and 905 Hz)

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14. ABSTRACT
The long-term goals of this work are to develop processing approaches that enable the estimation of both seafloor scattering strength and subbottom geoacoustic parameters from monostatic and bistatic scattering observations.

15. SUBJECT TERMS

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and (2) 1.6 – 4.4 kHz (CW tonals at 1.6, 2.4, 3.5, and 4.4 kHz). The monostatic backscatter data were collected at two center frequencies: (1) 850 Hz (small-aperture, 4-element source array with the data recorded on the 16-element VLA nearly collocated with the source) and (2) 3.5 kHz (using a 29-element, 78 m aperture source/receive array).

WORK COMPLETED

Initial geoacoustic inversion results have been completed for the low frequency source tow transmissions (195, 295, and 395 Hz).

RESULTS

The source tow tracks ran NW from the autonomous VLA. The geoacoustic model proposed for the experiment site is shown in Figure 1 and consists of two sediment layers over a basement half-space. The water depth in the source tow region is known to be approximately 105 m. The source tow data analyzed was collected on 7 June (Julian Day 158) 0310-0436 UTC.

Although CTD's were taken at the VLA prior to and after the source tow, the water column sound speed structure in the experiment area was very dynamic. Figure 2 shows the first six eigenfunctions obtained from an EOF analysis of the CTD's collected during the experiment. Coefficients for the first two eigenfunctions were included in the inversion.

Using source tow tonal data at 195, 295, and 395 Hz and a range of 2.8 km, SAGA (Seismo-Acoustic Genetic Algorithm [2]) was used to estimate parameters of the geoacoustic model in Figure 1 based on a Bartlett matched field objective function. In addition to EOF coefficients characterizing the water column sound speed structure, other parameters estimated included source range and depth, bathymetry, and two parameters characterizing the array shape (tilt and bow). These and the estimated waveguide geoacoustic parameters are tabulated in Figure 3.

As an indication of the quality of the estimated geoacoustic parameters, Figure 4 shows a Bartlett matched field ambiguity surface for these data averaged across the three frequencies.

IMPACT / APPLICATIONS

Geoacoustic inversion techniques are of general interest for the estimation of waveguide parameters thus facilitating system performance prediction in shallow water. Natural transition paths for these results will be SPAWAR (PMW-155) and NAVSEA (ASTO).

TRANSITIONS

No transitions took place in FY02.

RELATED PROJECTS

This project is one of several sponsored by ONR Code 321OA to participate in the East China Sea component of the ASIAEX program.

REFERENCES

[1] P.H. Dahl, "ASIAEX East China Sea Cruise Report of the Activities of the R/V Melville 29 May to 9 June 2001," APL-UW-TM 7-01, Applied Physics Laboratory, University of Washington (2001).

[2] P. Gerstoft, "SAGA User Manual 2.0: An Inversion Software Package," SM-333, SACLANT Undersea Research Centre, La Spezia, Italy (1997) (SAGA Ver. 4.1 is available at http://www.mpl.ucsd.edu/people/gerstoft/saga/saga.html).

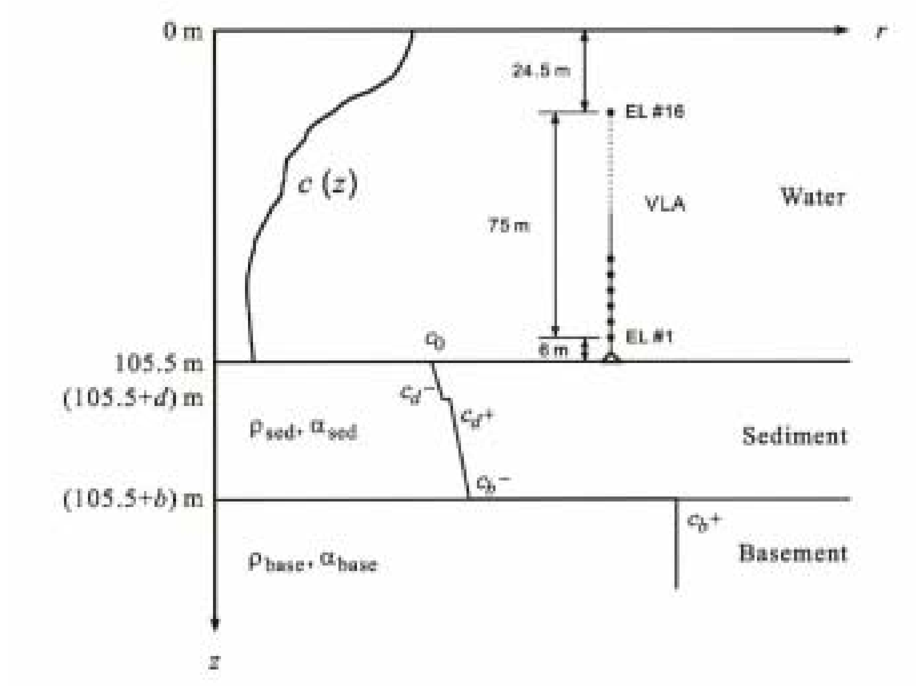

Figure 1. Geoacoustic model proposed for the experiment site consisting of two sediment layers over a basement half-space. The water depth in the source tow region is known to be approximately 105 m.

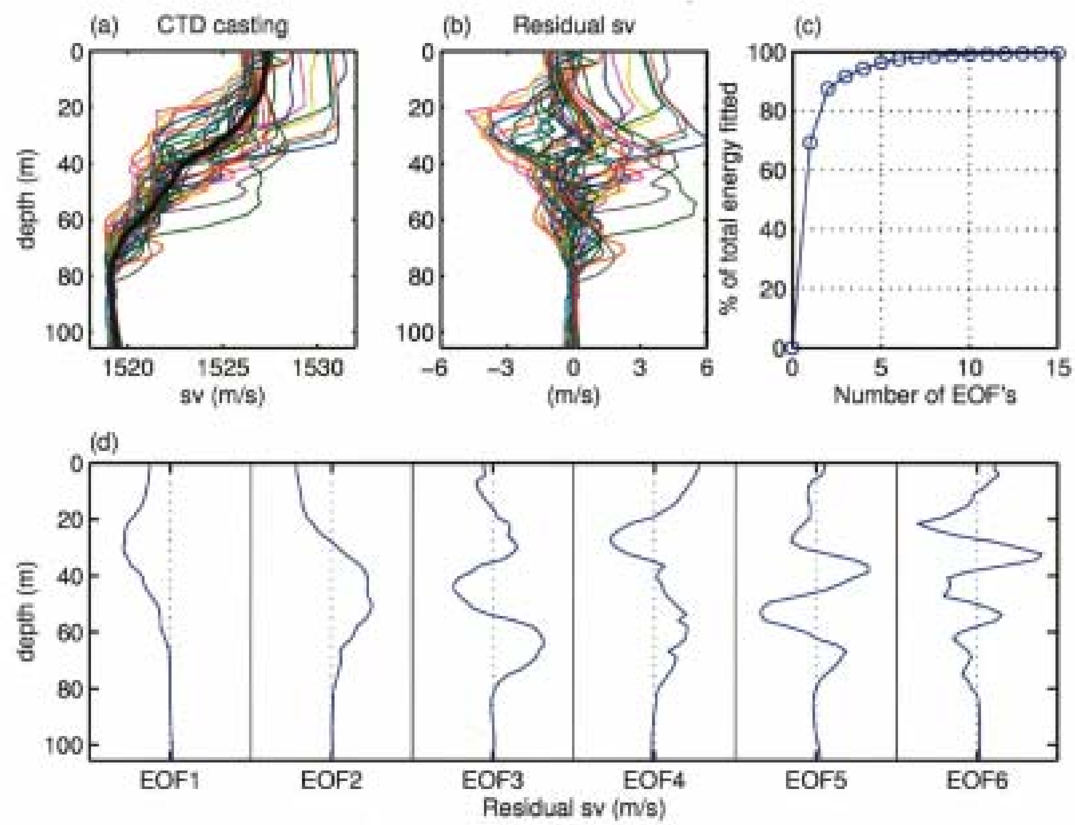

Figure 2. EOF analysis of the CTD's collected during the experiment. (a) Overplot of the CTD's (dark line is the mean sound speed profile). (b) Residuals about the mean profile. (c) Eigenvalue distribution. (d) First six eigenfunctions.

Model parameter	Value
Source range (m)	2832.67 (2798.0)
Source depth (m)	51.43 (49.0)
Geometric	
Bathymetry (m)	106.19 (105.5)
Array tilt (deg)	-6.83 (-6.0)
Bow of parabola (m)	1.42 (1.7)
Ocean sound speed	
EOF 1	6.382 (6.766)
EOF 2	-3.246 (-2.495)
EOF 3	– (-0.756)
EOF 4	– (2.178)

Geoacoustic	
Sediment	
Comp. speed, c_0 (m/s)	1585.23
Comp. speed, c_{d^-} (m/s)	1614.14
Comp. speed, c_{d^+} (m/s)	1633.82
Comp. speed, c_{b^-} (m/s)	1686.08
Density (g/cm^3)	1.709
Attenuation (dB/λ)	0.299
Depth of $d^\pm$ (m)	12.19
Depth of $b^\pm$ (m)	45.30
Subbottom	
Comp. speed, c_{b^+} (m/s)	2240.50
Density (g/cm^3)	2.4
Attenuation (dB/λ)	0.032

Figure 3. SAGA (Seismo-Acoustic Genetic Algorithm) parameter estimates from the source tow tonal data at 195, 295, and 395 Hz and a range of 2.8 km.

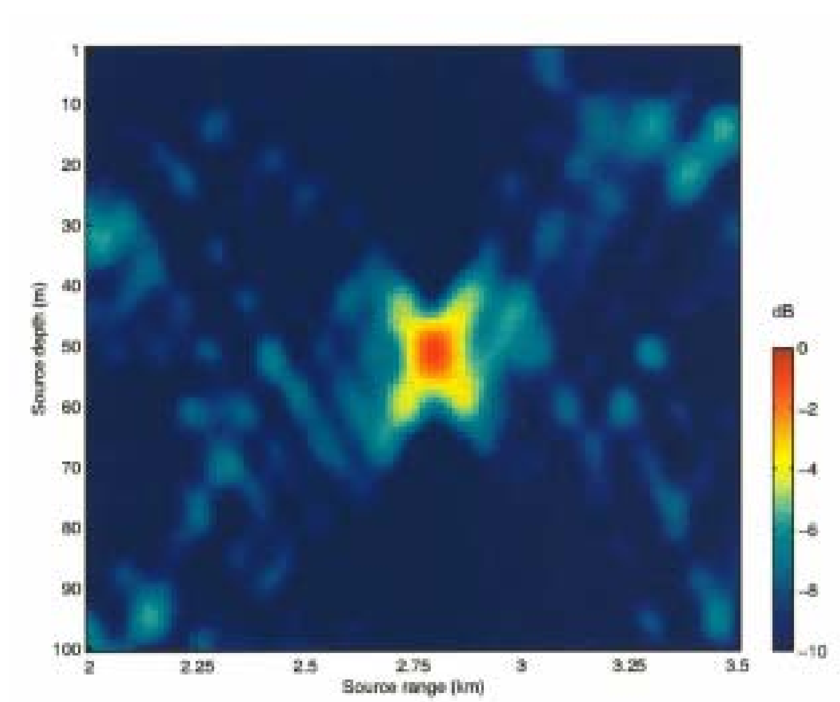

Figure 4. Bartlett matched field ambiguity surface for the source tow data averaged across three frequencies (195, 295, and 395 Hz).